III.E.5 Foil-Bearing Supported High-Speed Centrifugal Cathode Air Blower

Objective

Design a foil-bearing supported high-speed centrifugal cathode air blower (CAB) meeting all the technical requirements of SECA members and develop a process to reduce the manufacturing cost of CABs to $100 per unit based upon a production volume of 50,000 units/year.

Accomplishments

- The project is in the early stages of CAB design.
- Initial CAB design point performance calculations were made.

Introduction

The goal of the Solid State Energy Conversion Alliance (SECA) is to develop commercially-viable ($400/kW) 3 to 10 kW solid oxide fuel cell (SOFC) systems by year 2010. SOFC power generation systems are attractive alternatives to current technologies in diverse stationary, mobile, and military applications. SOFC systems are very efficient, from 40 to 60 percent in small systems and up to 85 percent in larger cogeneration applications. The electrochemical conversion in a SOFC takes place at a lower temperature (650 to 850ºC) than combustion-based technologies, resulting in decreased emissions – particularly nitrogen oxides, sulfur oxides, and particulate matter. These systems all offer fuel flexibility, as they are compatible with conventional fuels such as hydrogen, coal, natural gas, gasoline, or diesel. Despite these advantages, advances in balance of plant (BOP) component design must be developed before the SECA program goal can be realized.

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SOFC systems require blowers to provide motive force to incoming atmospheric air, in order to overcome the pressure drop in the various valves and heat exchangers, and in the fuel cell stack. The energy required to drive this component is typically one of the largest parasitic loads for the SOFC system; consequently, high blower efficiency is paramount to high system efficiency. Furthermore, blower reliability is critical to ensure safe long-term system operation.

Approach

- In Phase I, a CAB will be concepted and designed based on a previously developed fuel processor blower. A process will be developed for reducing the manufactured cost of CABs to $100 per unit, based upon a production volume of 50,000 units per year.
- In Phase II, a detailed design of the CAB will be completed and a prototype manufactured and tested using cost reduction techniques identified in Phase I.
- Phase III will start the commercialization phase of the project. CAB field demonstrations will be initiated with SECA members and other potential original equipment manufacturers. Distributors will be identified and contacted.

Results

A preliminary design has been performed. The CAB has been designed as a centrifugal compressor running at 80,500 rpm. In order to meet high reliability, the rotating assembly will be supported on foil air bearings.

The proposed CAB will be driven by a brushless permanent magnet DC motor or switched reluctance motor. Such motors have shown high efficiency and high reliability for the power range required for the CAB.

The cathode air blower will be similar to a previously designed, manufactured and successfully tested proton exchange membrane fuel processor system (FPS) air blower, which was built by R&D Dynamics for UTC Fuel Cells under a DOE-funded project. The FPS blower is shown in Figures 1 and 2. It is foil-bearing supported and is of a high-speed centrifugal type design. The CAB will be affordable, efficient, reliable, small, lightweight, and meet turndown requirements.

The FPS rotating assembly, shown in Figure 3, is made up of the impeller, journal bearing shaft, motor rotor, thrust bearing shaft and hall magnet assembly. The shaft components are held together in compressive preload by a tie rod that runs through the center of the shaft. The resulting rotating assembly is extremely lightweight and rigid.

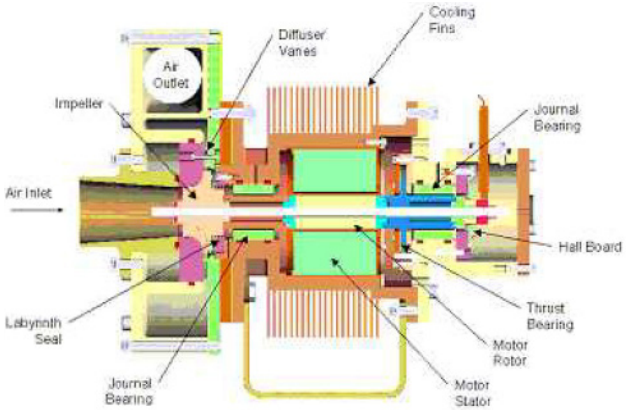

FIGURE 1. Cut Away View of FPS Blower

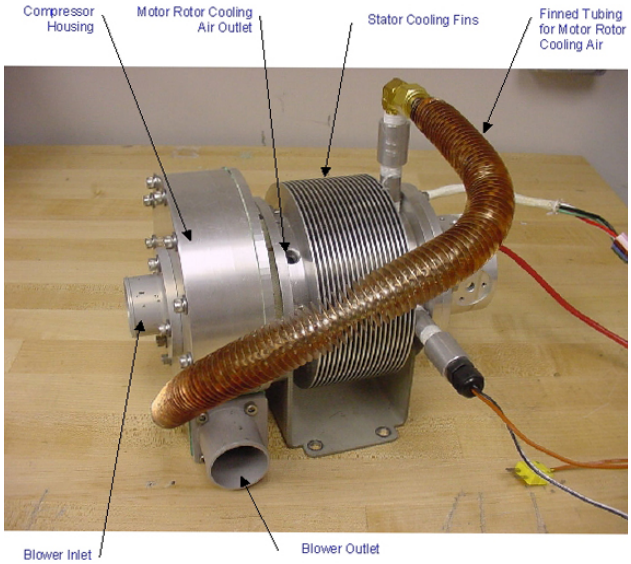

FIGURE 2. Actual FPS Blower

FIGURE 3. FPS Blower Rotating Assembly

CAB Technical Requirements

Specific blower performance requirements are dependent upon the design of the SOFC system with which it is associated; nevertheless, the following representative nominal requirements, in lieu of design-specific data, will be addressed:

Fluid Type	Atmospheric Air
Pressure Ratio	1.1 to 1.2
Peak Airflow	1,500 SLPM
Speed Control	Variable Speed
Turn-Down Ratio	5:1
Overall Efficiency	≥60%
Design Life	>40,000 hours @ 100% Duty Cycle
Maintenance	Interval >10,000 hours
Target Cost	<$100 per unit based on 50,000 units/year
Noise	<70 dBA
Contamination of Process Air	None desired

Preliminary Performance of CAB Blower (Design Point)

Type	Centrifugal
Impeller Diameter	1.67 inches
Inlet Pressure	14.7 psia
Inlet Temperature	68°F
Outlet Pressure	17.64 psia
Outlet Temperature	103.7°F
Pressure Ratio	1.2
Mass Flow Rate	3.98 lbm/min
Adiabatic Efficiency	79%
Speed	80,500 rpm

Conclusions and Future Directions

The project has encountered no technical or manufacturing cost barriers to date which would prevent the objectives from being met.